RESEARCH CIRCULAR 209 DECEMBER 1975

# Mass Sorting of Mechanically Harvested Tomatoes

WILBUR A. GOULD

OHIO AGRICULTURAL RESEARCH AND DEVELOPMENT CENTER
Wooster, Ohio

## CONTENTS

* * * *



## ACKNOWLEDGMENTS

The author is deeply indebted to the Tomato Research Committee of the Ohio Canners and Food Processors Association for planning this project. The committee consisted of Richard Boucher, Bryan Canning Co.; Fred Binger, Libby, McNeill & Libby; William Hirzel, Hirzel Canning Co.; Thomas H. Timmer, Tip Top Canning Co.; Rodney Wohlers, Hunt-Wesson Foods; Henry Reichman, Libby, McNeill & Libby; Lynn Roseman, FMC Corporation; Jack Scheid, Chisholm Ryder Co.; and Dr. H. A. Rollins, Jr., The Ohio State University and Ohio Agricultural Research and Development Center. Appreciation is expressed to the following firms for substantial financial contributions: Beckman & Gast Co., St. Henry; Bryan Canning Co., Bryan; Del Monte Corp., Rochelle, Ill.; H. J. Heinz Co., Bowling Green and Fremont; Hunt-Wesson Foods, Toledo; Libby, McNeill & Libby, Leipsic; Minster Canning Co., Minster; Stemley Canning Co., New Weston; and Tip Top Canning Co., Tipp City. The author is grateful to the following firms for loaning equipment: General Kinetics Inc., Rockville, Md.; Libby, McNeill & Libby, Leipsic; and Hirzel Canning Co., Toledo; and to the following firms and personnel for significant contributions throughout the study: Libby, McNeill & Libby: Fred Binger, Larry Holl, Henry Reichman, Ken Holloway, Tom Valvoda, and Dave Schultz; FMC Corporation: Lynn Roseman; Chisholm Ryder Corp.: Jack Scheid; and OARDC-OSU personnel: Betty Fogg, Jacquelyn Gould, James Ice, Deanna Johnson, Donald Mount, John Mount, LaVon Riegel, Marilynn Skoog, Jerry Stillabower, Ruth Stillabower, Cheryl Thompson, Judy Wheeland, and Jerry Wright. Appreciation is expressed to the Ohio Canners and Food Processors Association for sponsoring the cost of the color printing.

AGDEX 257/54-78

12-75-2.5M

# Mass Sorting of Mechanically Harvested Tomatoes

WILBUR A. GOULD[1]

## INTRODUCTION

At the present time mechanical harvesting of tomatoes is a reality, at least in the Western U. S. In the Midwest, due to the lack of uniformity of fruit ripening, 70% or more of the tomato crop is still hand harvested. However, with new tomato cultivars, the use of ethephon, and insufficient labor for hand harvesting, mechanical harvesting of tomatoes may be a reality in the Midwest in the immediate years ahead.

Most authorities agree that when mechanical harvesting becomes a full reality in the Midwest, it will not be economically feasible to utilize the present amount of labor on the harvester to sort the tomatoes into useable and unuseable fruits. This is probably more critical in the Midwest than in the West as the weather conditions do not permit uniform field ripening. Alternative methods of sorting the crop other than on the tomato harvester are needed.

The quality of processed tomatoes is directly related to the quality of the raw tomato. Quality includes color (maturity), freedom from defects and soil, and other attributes. Raw tomato maturity for processing implies the percentage of red color determined subjectively or the new USDA standard using the tomato colorimeter for tomato pulp color. Generally, the raw tomato color is defined as the percentage of Number 1's or Number 2's, with Number 1 having 90% red color and Number 2 with 66⅔% red color or the TCM value of 63 or more.

Another measure of tomato maturity is specific gravity or percent tomato solids. Even though the change of maturity may be small, the specific gravity is significant and tomatoes can be evaluated for maturity by specific gravity separation techniques.

Kattan *et al.* in 1968 and 1969 reported on the Food Technology Corporation (FTC) mass mechanical sorter for tomatoes using brine solutions (1 and 2). Gutterman has shown that mass quality separation of tomatoes utilizing the differences of specific gravity between green and defective fruit vs. ripe and sound fruit can be obtained by separation in a body of water using the FTC sorter (3).

## OBJECTIVES

The basic objectives of this study were to determine: 1) the feasibility of mechanically harvesting tomato cultivars with little or no labor for sorting of fruits on the harvester, 2) the feasibility of mass sorting mechanically harvested tomatoes by cultivars for quality at the processing plant utilizing the water separation techniques, and 3) the potential of dry cleaning tomatoes with the Western Regional Utilization Laboratory disc system.

## PILOT LINE LAYOUT

A pilot line was designed at the Libby, McNeill & Libby plant at Leipsic, Ohio, to handle a minimum of 3 tons of tomatoes per hour in lots of approximately 1,000 lb. A schematic layout of the line is shown in Figure 1. The line consisted of a dump tank, 2; a conveyor out of the dump tank, 3; vine and trash conveyor eliminator, 4; dry disc cleaner, 5; modified FTC water separator, 6, with three take-off belts and controls for water velocity, air injection, and water temperature control; and three sorting belts, 7, 8, 9. In addition, facilities for collection and weighing different qualities of fruits and the determination of specific gravity from each sorting belt were part of the pilot line. A detailed layout of the mass specific gravity separator is shown in Figure 2. Photos A-F, Figure 3, give further visual description of the line.

## PROCEDURES

### Cultivars

Four cultivars (Libby A, Libby B, C-28, and a pear cultivar) grown and supplied by the Libby, McNeill & Libby firm were used for the basic studies. With the exception of cultivar C-28 which was hand harvested for the first two runs, all lots were machine harvested. There was little or no sorting on the harvester other than eliminating the large clods of dirt and vines and removing useable fruit from the dirt belt. Approximately 56,000 lb. of fruit were used from the Libby firm.

Thirteen cultivars were harvested from the cultivar evaluation plots at the OARDC Northwestern Branch near Hoytville. These were likewise machine harvested with little or no sort on the harvester except as noted above. Approximately 1 ton of fruit was harvested from each cultivar, with a total of 24,595 lb. These 13 cultivars were averaged and treated as one lot. In all, 80,778 lb. of fruit were harvested and water sorted in 73 separate runs during the season.

### Quality of Fruit

As the tomatoes were run by each specific cultivar, the percent useable fruits (theoretical reds) were determined visually on the basis of color. Further, the specific gravity was calculated on a 5-8 lb. sample of both the useable and unuseable fruits by weighing

[1]Professor of Horticulture, The Ohio State University and Ohio Agricultural Research and Development Center.

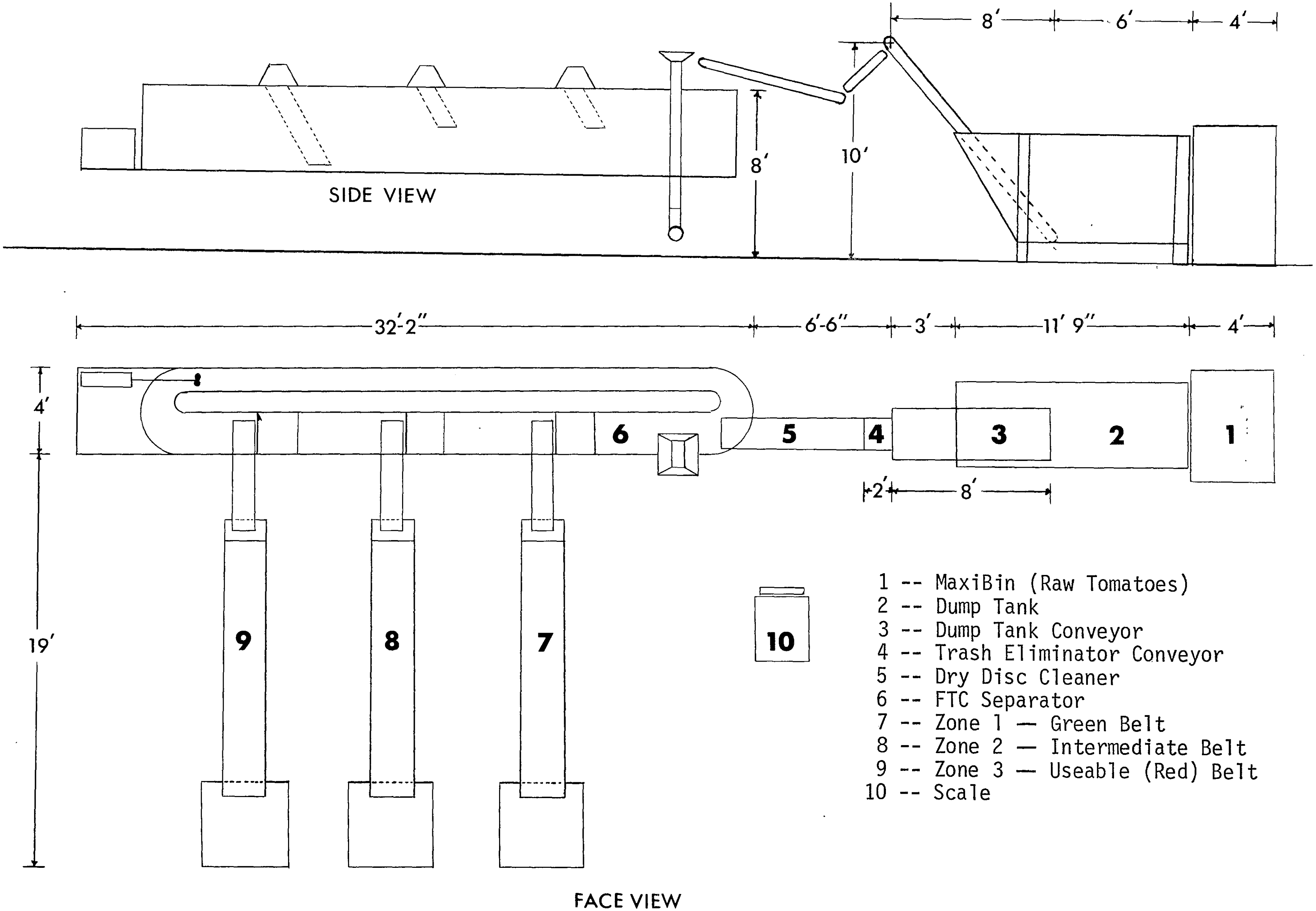



FIG. 1.—Layout of pilot line for cleaning and water separation of tomatoes.

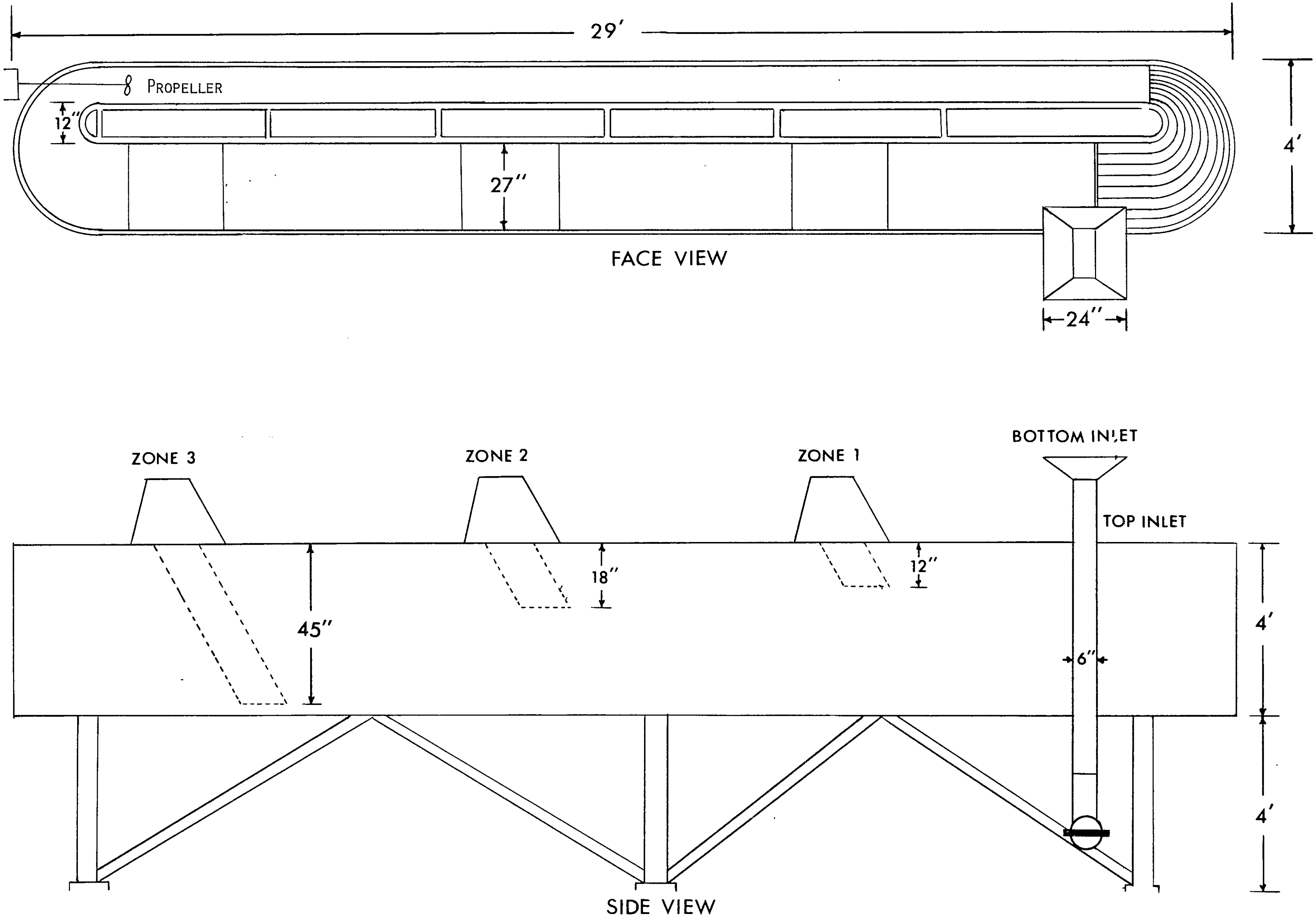



**FIG. 2.—FTC mass specific gravity separator.**

the sample in air and in water. The weights of both the useable and unuseable fruits were recorded from all take-off conveyors for each run and were used to determine the efficiency of the mass sorting operation.

**Quality of Water**

The water in the dump tank and the specific gravity separator was sampled at the start, during, and at the end of each day's run. The samples were evaluated for changes in pH, soluble solids, total solids, total volatile solids, volatile suspended solids, and chemical oxygen demand (COD) using standard methods.

**Pilot Line Operation**

Generally, 1,000 lb. of tomatoes of each cultivar were dumped in the dump tank at the rate of 100 lb. per minute while the pilot line was in operation. The only adjustments made during a run were: 1) the velocity of the water in the mass specific gravity separator ranging from 550 to 800 r.p.m. on the propeller; 2) the level of the water which controlled the depth of the take-off conveyor in zones 1 and 2; 3) the location of the take-off conveyors for zones 1 and 2 with respect to the entry of the fruit in the water; 4) the temperature of the water from ambient up to 100° F.; and 5) the use of a detergent in the mass specific gravity separator. During the early runs, an additional variable consisted of feeding the tomatoes in the bottom of the tank as originally designed on the FTC unit vs. direct feed into the top of the unit. Most of the data were taken by direct feed as the FTC method caused a plugging of the unit, particularly with the pear-shaped cultivar.

## RESULTS

The average theoretical reds (mature ripe fruit) varied by cultivars from a low of 48.5% reds for the average of the cultivars from the OARDC lot to a high of 97.4% reds for the Libby pear variety. The actual reds water sorted ranged from a low of 43.8% for the OARDC lot to a high of 84.8% for the C-28 variety (Table 1). The detailed data for each cultivar by run are presented in Appendix Tables I-A through I-Q, available from the author.[2]

The data in Figure 4, theoretical vs. actual weights of reds, show a correlation of .87 for the various runs throughout the season. The data in Figure 5 show the theoretical reds and actual reds in percent, with pounds and calculated efficiencies for each of the cultivar lots. The tomatoes in Figure 3-G are typical of some of the lots as received prior to dumping. The tomatoes shown in Figures 3-H and 3-I are the actual separation as done in the separator for those raw tomatoes shown in Figure 3-G.

The data in Table 1 summarize the totals or averages for the runs by cultivars or lots for the season. The important comparisons are in percent useable or theoretical reds vs. the percent useable sorted or actual reds. As an example, for Libby A there were 28,537 lb. sorted, with a percent useable or theorectical reds of 74.4% and actual reds water separated in zone 3 of 66.4%. For Libby B, there were 18,284 lb. with 68.7% vs. 41.9%. Considerable more difficulty was encountered with this cultivar for some of the runs, causing the percentages to be down. However, as adjustments were made between the runs with the cultivar, the data indicate that it can be separated nearly as efficiently as the Libby A cultivar. With the C-28 cultivar, the percent useable for the 6,988 lb. was 79.2% theoretical red with an actual separation of 76.4%.

The 13 OARDC cultivars amounted to a total of 24,595 lb. with only an average of 48.5% theoretical ripe. However, the average separation for all cultivars was 36.6%

Another way to interpret the data is to calculate the percent efficiency of the separator by taking the total pounds of useable fruit separated in zone 3 over the total pounds of useable fruit in all three zones (theoretical reds). These calculations show an overall efficiency of 80.0% for 80,778 lb., with a low of 61.0% efficiency for Libby B and a high of 97.0% efficiency for C-28.

The data in regards to monitoring the changes in water quality for the separator are shown in Figures 6-10. The detailed data for each day's run are presented in Appendix Table II. Generally it will be noted that there was not an excessive buildup of fixed, volatile, soluble, or total solids in the separator. Further, the chemical oxygen demand (COD) values were extremely low. The COD values in the cleaner and dump tank were much higher than in the separator. This was caused by the wide range of soil or dirt coming in with the harvested fruit during the wet weather for some of the harvests.

These data clearly indicate the ability of the disc cleaner to clean the fruit before being water separated. In Figure 8, the zero values for soluble solids indicate that there is no increase in soluble solids. For the two runs on August 27 and Sept. 18, the COD separator values were very low, indicating that very clean tomatoes were entering the separator.

[2]Appendix Tables I-A through I-Q and Appendix Table II are contained in a supplement to this circular. Copies are available from Dr. Wilbur A. Gould, 055 Howlett Hall, 2001 Fyffe Court, Columbus, Ohio 43210.

**TABLE 1.—Summary Evaluation of Water Separation of Tomatoes by Cultivars Showing Weights and Calculated Percentages by Separator Zones and Efficiency.**

| Code for Calculations* | | Pear | Libby A | Libby B | C-28 | OARDC | Total or Average |
|---|---|---|---|---|---|---|---|
| 1 | Number of Runs | 3 | 21 | 17 | 6 | 26 | 73 |
| 2 | Total Weight (lb.) Separated | 2,554.0 | 28,357.0 | 18,284.0 | 6,988.0 | 24,595.0 | 80,778.0 |
| 3 | Percent Useable (Theoretical Red) | 97.4 | 74.4 | 68.7 | 79.2 | 48.5 | 66.4 |
| 4 | Percent Unuseable (Theoretical Green) | 2.6 | 25.6 | 31.3 | 20.8 | 51.5 | 33.6 |
| 5 | Specific Gravity Useable | 1.109 | 1.102 | 1.086 | 1.145 | 1.093 | 1.107 |
| 6 | Specific Gravity Unuseable | 1.074 | 1.027 | 1.029 | 1.090 | 1.049 | 1.053 |
| 7 | Zone 1 Useable (lb.) | 342.0 | 1,670.0 | 4,129.0 | 68.0 | 2,441.0 | 8,650.0 |
| 8 | Useable (%) | 85.1 | 23.8 | 45.5 | 10.4 | 19.2 | 29.0 |
| 9 | Zone 1 Unuseable (lb.) | 60.0 | 5,357.0 | 4,948.0 | 589.0 | 10,259.0 | 21,213.0 |
| 10 | Unuseable (%) | 14.9 | 76.2 | 54.5 | 89.6 | 80.8 | 71.0 |
| 11 | Zone 2 Useable (lb.) | 185.0 | 574.0 | 776.0 | 125.0 | 473.0 | 2,133.0 |
| 12 | Useable (%) | 97.9 | 62.1 | 74.7 | 30.8 | 42.2 | 58.0 |
| 13 | Zone 2 Unuseable (lb.) | 4.0 | 351.0 | 263.0 | 281.0 | 648.0 | 1,547.0 |
| 14 | Unuseable (%) | 2.1 | 37.9 | 25.3 | 69.2 | 57.8 | 42.0 |
| 15 | Zone 1 + Zone 2 Useable (lb.) | 527.0 | 2,244.0 | 4,905.0 | 193.0 | 2,914.0 | 10,783.0 |
| 16 | Useable (%) | 89.2 | 28.2 | 48.5 | 18.2 | 21.1 | 32.2 |
| 17 | Zone 1 + Zone 2 Unuseable (lb.) | 64.0 | 5,708.0 | 5,211.0 | 870.0 | 10,907.0 | 22,760.0 |
| 18 | Unuseable (%) | 10.8 | 71.8 | 51.5 | 81.8 | 78.9 | 67.8 |
| 19 | Zone 3 Useable (lb.) | 1,961.0 | 18,839.0 | 7,665.0 | 5,340.0 | 9,005.0 | 42,810.0 |
| 20 | Useable (%) | 99.9 | 92.3 | 93.8 | 90.1 | 83.6 | 90.6 |
| 21 | Zone 3 Unuseable (lb.) | 2.0 | 1,566.0 | 503.0 | 585.0 | 1,769.0 | 4,425.0 |
| 22 | Unuseable (%) | .1 | 7.7 | 6.2 | 9.9 | 16.4 | 9.4 |
| 23 | Total Zone 1 + Zone 2 (lb.) | 591.0 | 7,952.0 | 10,116.0 | 1,063.0 | 13,821.0 | 33,543.0 |
| 24 | Total Zone 1 + Zone 2 (%) | 23.1 | 28.0 | 55.3 | 15.2 | 56.2 | 41.5 |
| 25 | Total Zone 3 (lb.) | 1963.0 | 20,405.0 | 8,168.0 | 5,925.0 | 10,774.0 | 47,235.0 |
| 26 | Total Zone 3 (%) (Useable + Unuseable) | 76.9 | 72.0 | 44.7 | 84.8 | 43.8 | 58.5 |
| 27 | Percent Useable (Actual Reds) Sorted | 76.8 | 66.4 | 41.9 | 76.4 | 36.6 | 53.0 |
| 28 | Calculated Efficiency (Useable Fruit) | 79.0 | 89.0 | 61.0 | 97.0 | 76.0 | 80.0 |

*3=(15+19/2) x 100. 4=(17+21/2) x 100. 8=(7/7+9) x 100. 10=(9/7+9) x 100. 12=(11/11+13) x 100. 14=(13/11+13) x 100. 16=(15/23) x 100. 18=(17/23) x 100. 20=(19/19+21) x 100. 22=(21/19+21) x 100. 24=(23/2) x 100. 26=(25/2) x 100. 27=(19/2) x 100. 28=(19/15+19) x 100.

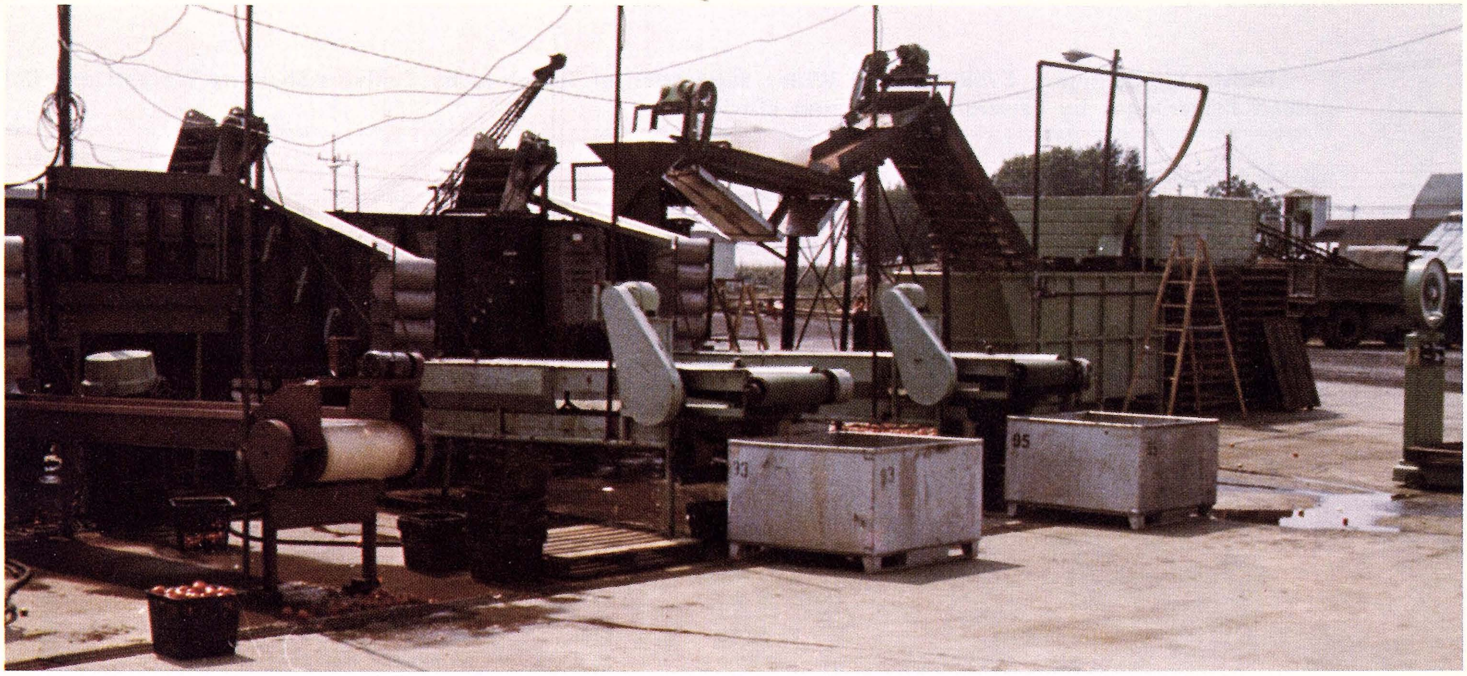


FIG. 3-A.—Overall experimental pilot line for dumping, cleaning, and sorting tomatoes.

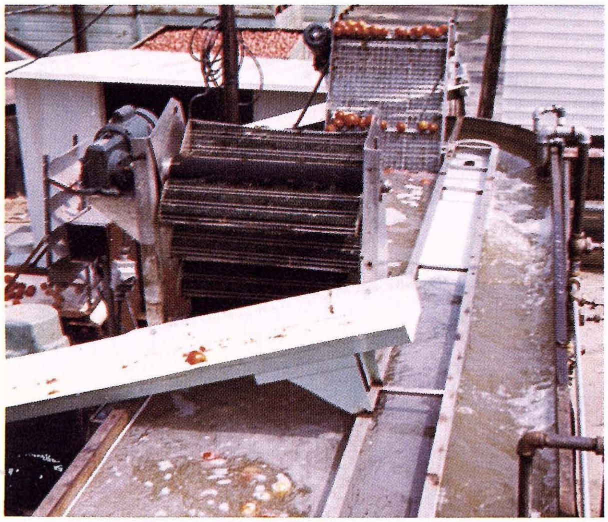


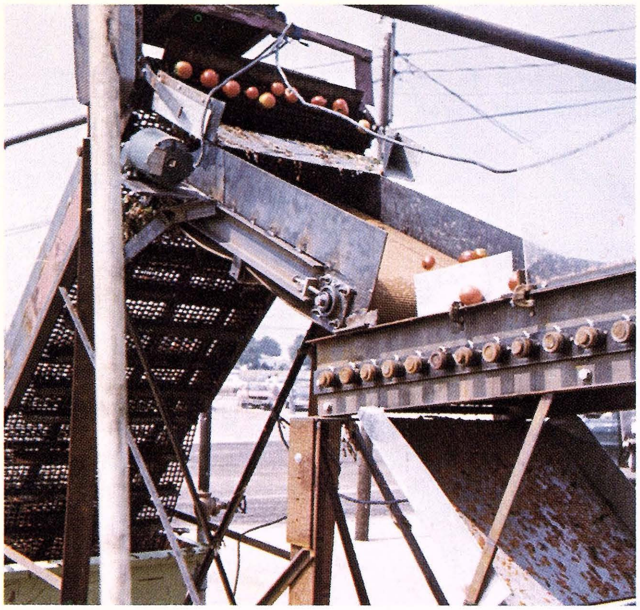
FIG. 3-D.—Specific gravity separator.

FIG. 3-E.—Green s
toes coming from s
tor zone 1.

FIG. 3-F.—Red s
coming from s
zone 3.

FIG. 3-G.—Raw product as received from the mechanical harvesters with no sort.

FIG. 3-H.—Specific gravity separated g



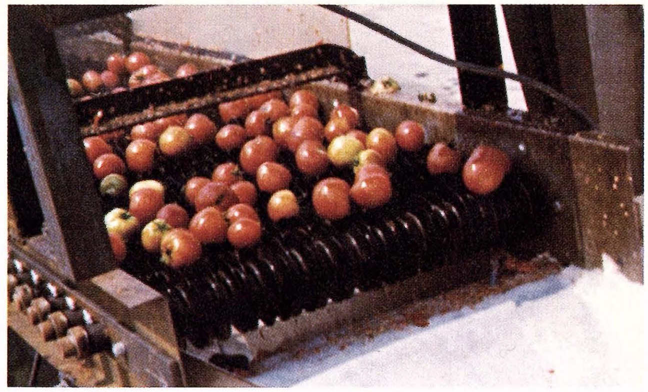
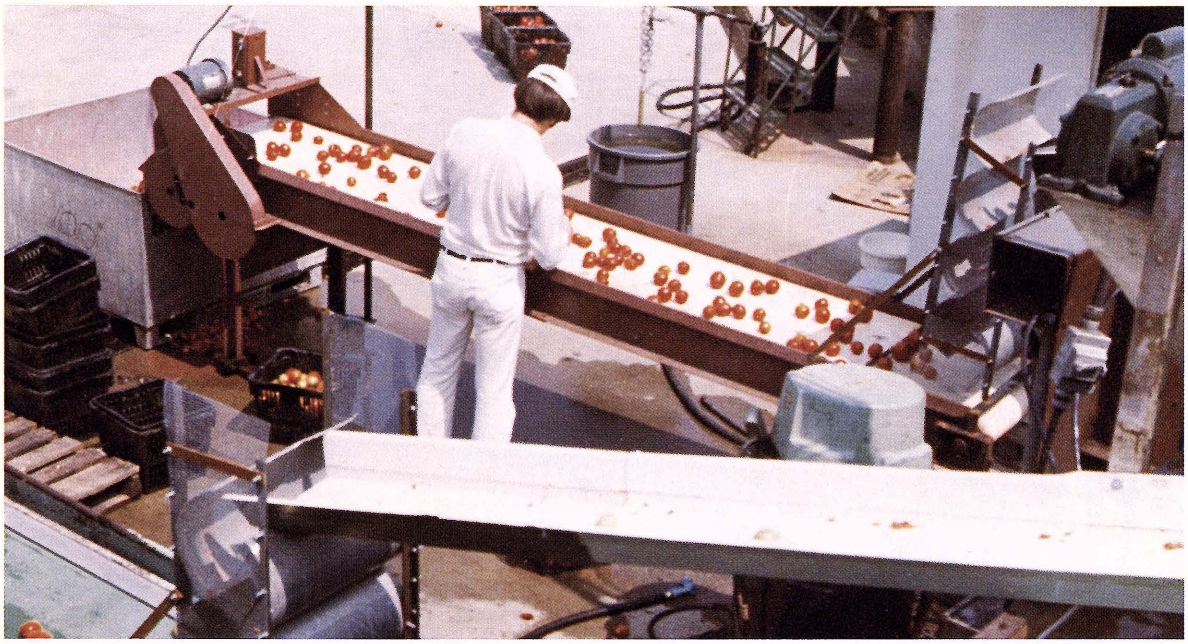


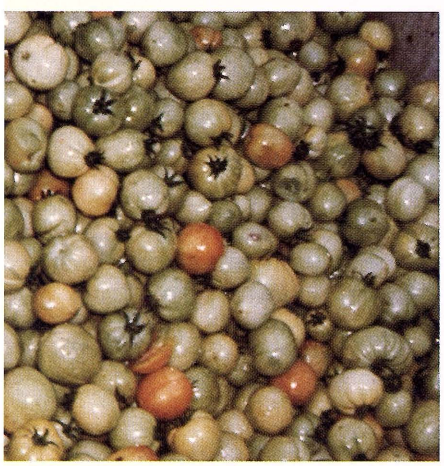
FIG. 3-C.—Dry disc cleaner.

FIG. 3-B.—Dumping tomatoes in water dump tank, showing conveyor removal of tomatoes from dump tank and vine and trash eliminator belt.

ıg belt with toma-
fic gravity separa-



ng belt with tomatoes
fic gravity separator



fruits from tomatoes shown in Fig. 3-G.

FIG. 3-I.—Specific gravity separated red fruits from tomatoes shown in Fig. 3-G.

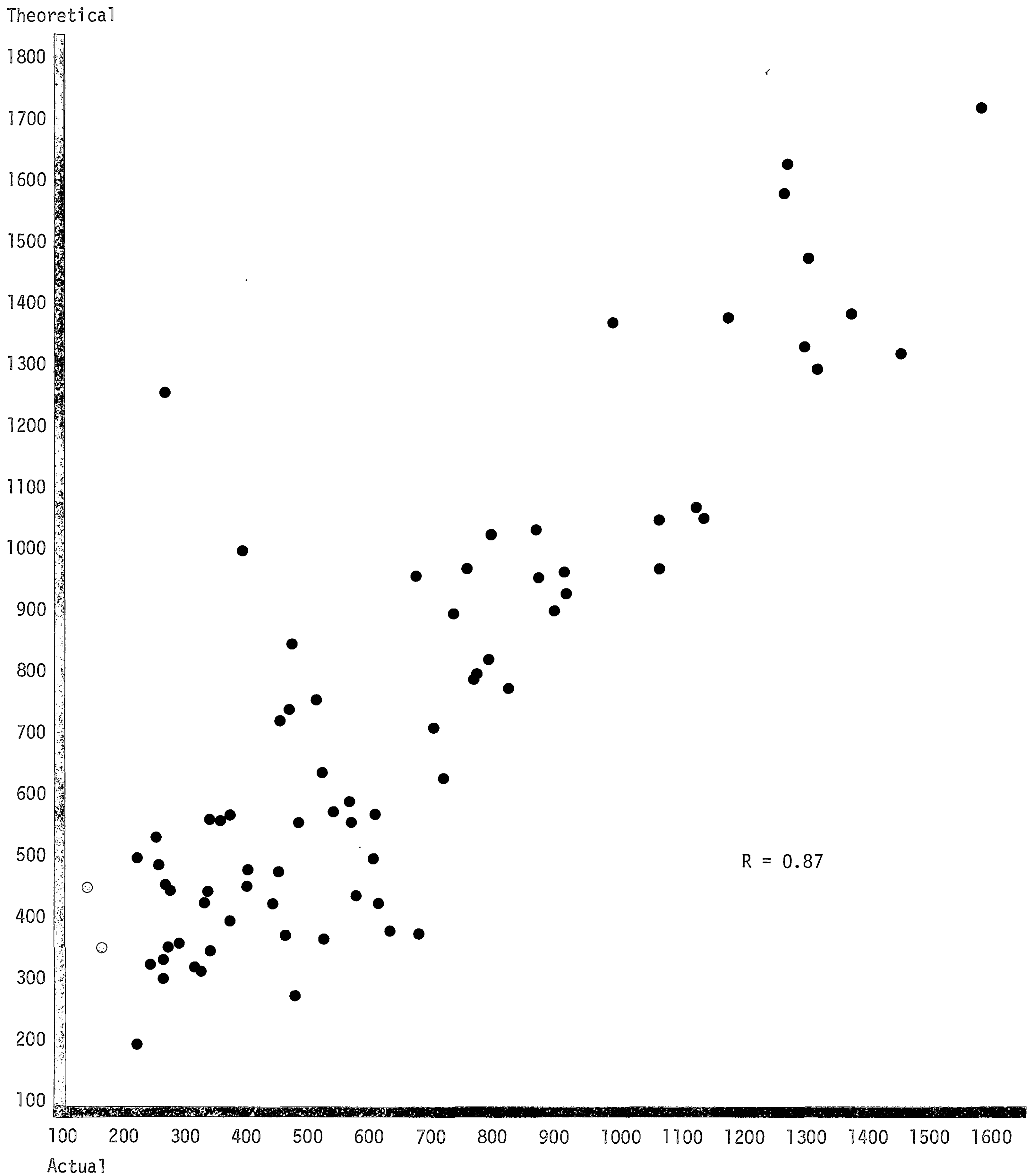



FIG. 4.—Theoretical vs. actual weights of reds.

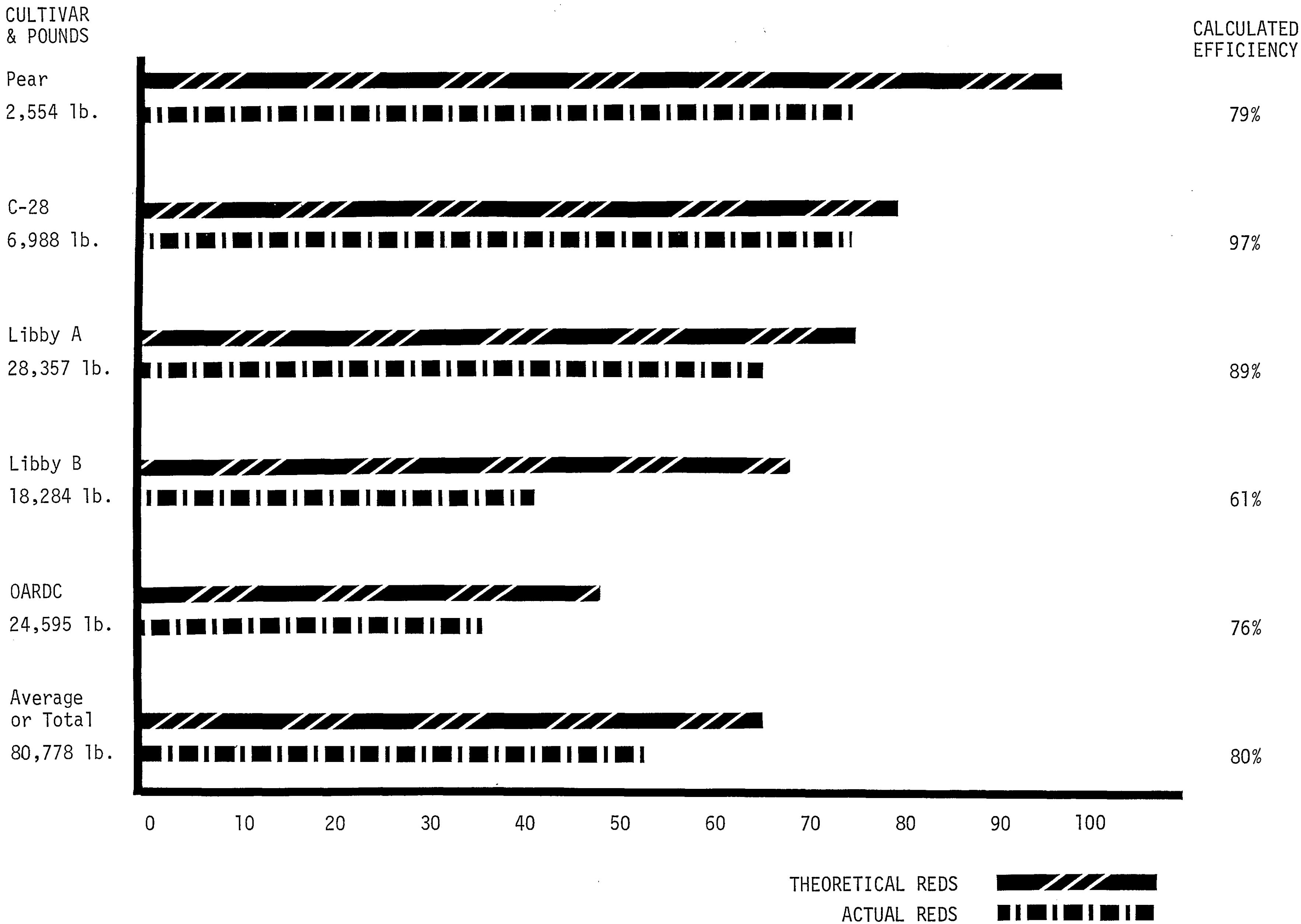



**FIG. 5.—Comparison of theoretical reds vs. actual specific gravity separated reds in percent by cultivars, with total pounds and calculated efficiency.**

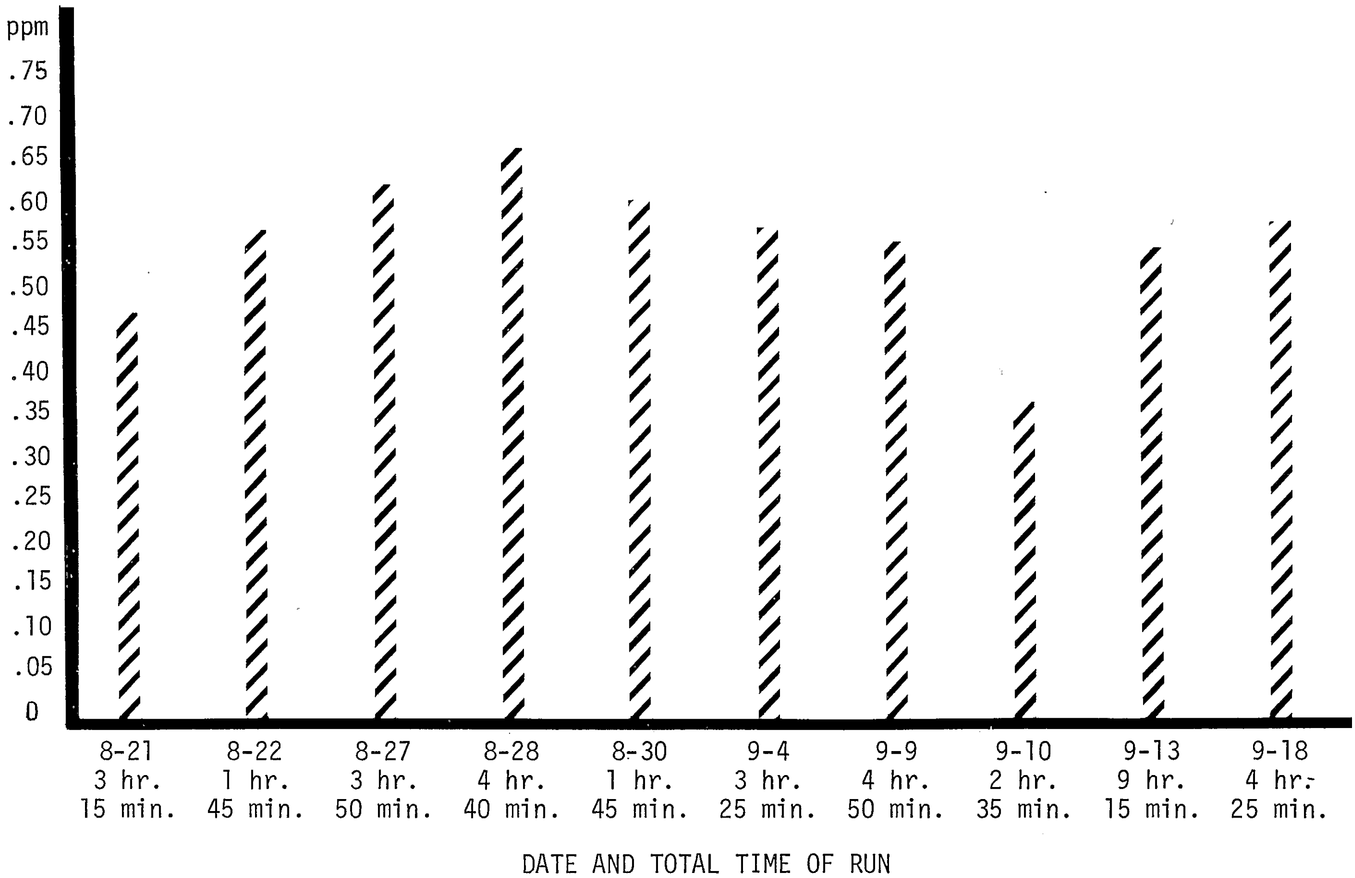



**FIG. 6.—Increase in total fixed solids for separator by each day's run.**

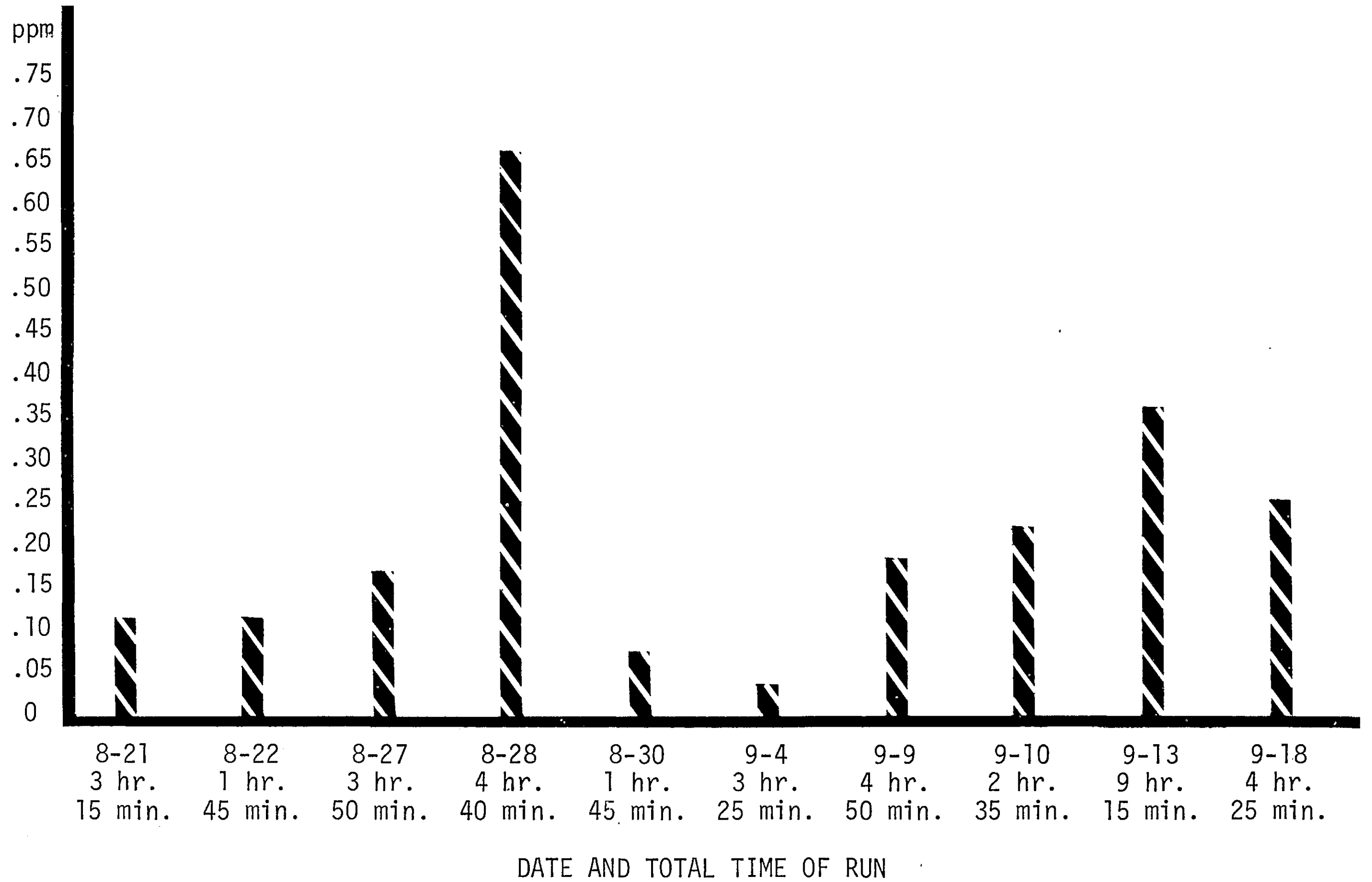



**FIG. 7.—Increase in total volatile solids for separator by each day's run.**

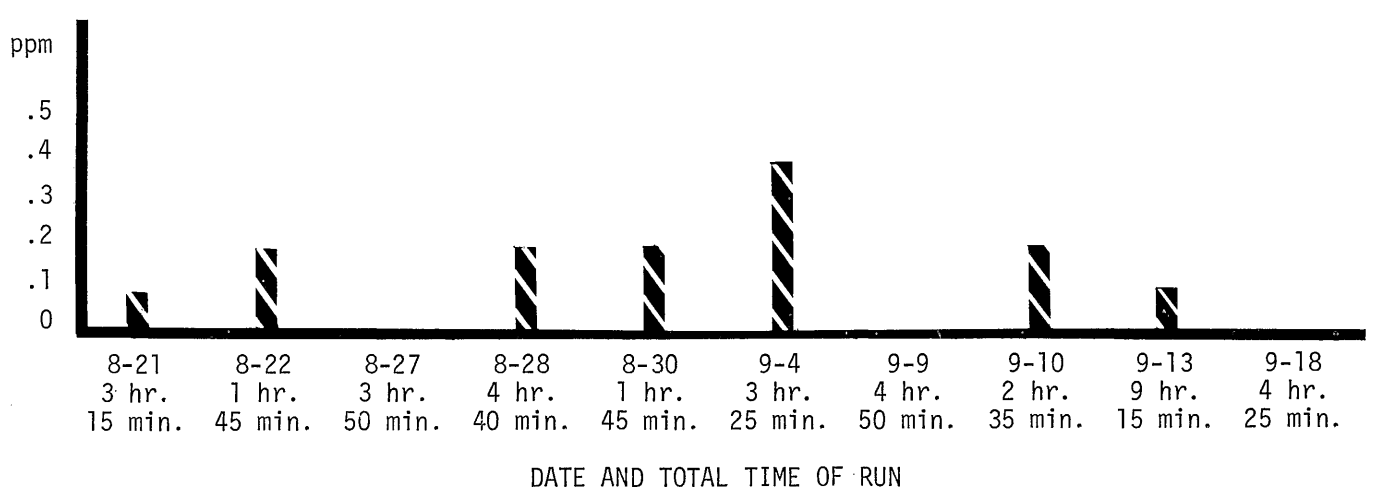



**FIG. 8.—Increase in soluble solids for separator by each day's run.**

FIG. 9.—Increase in total solids for separator by each day's run.

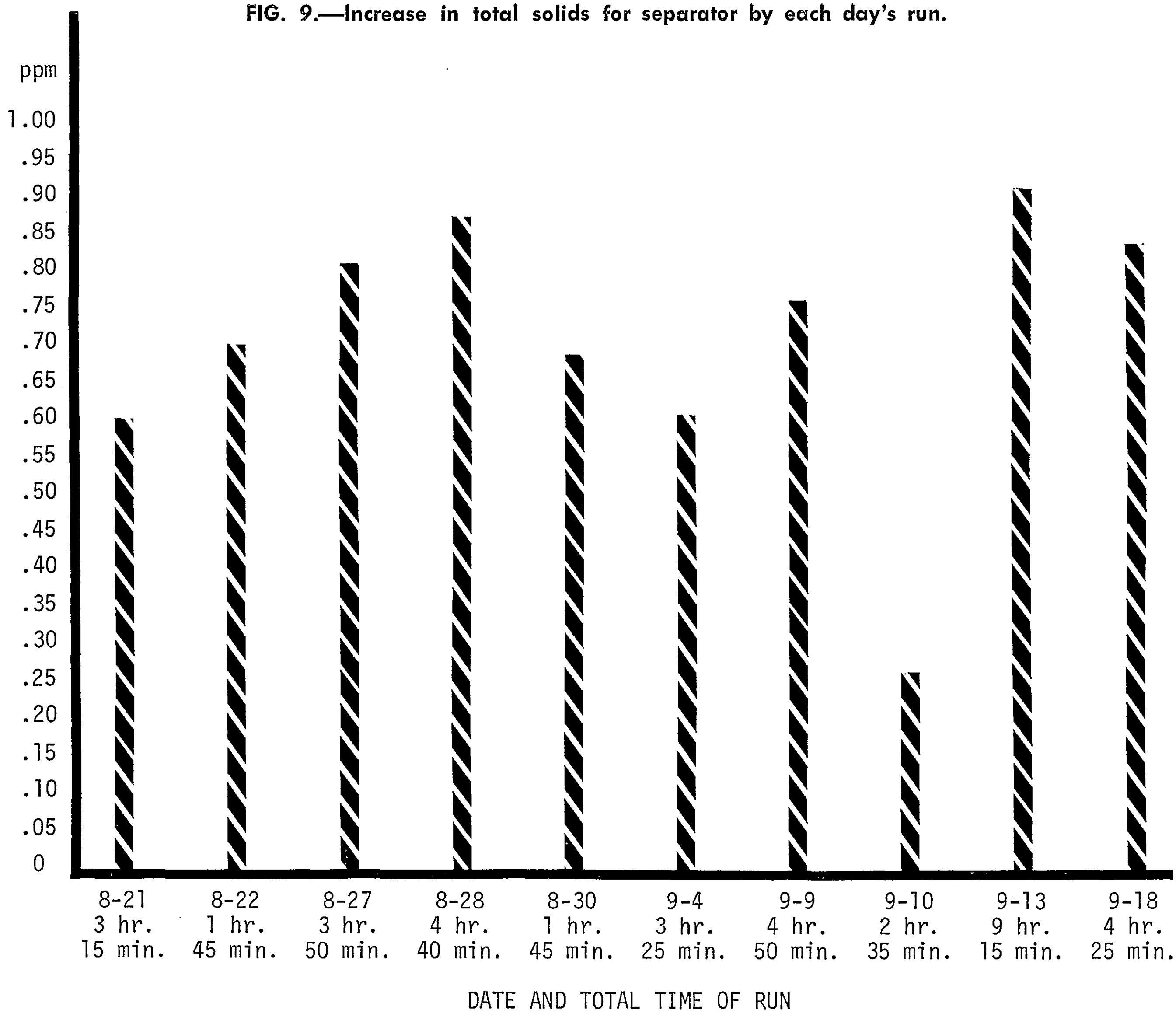
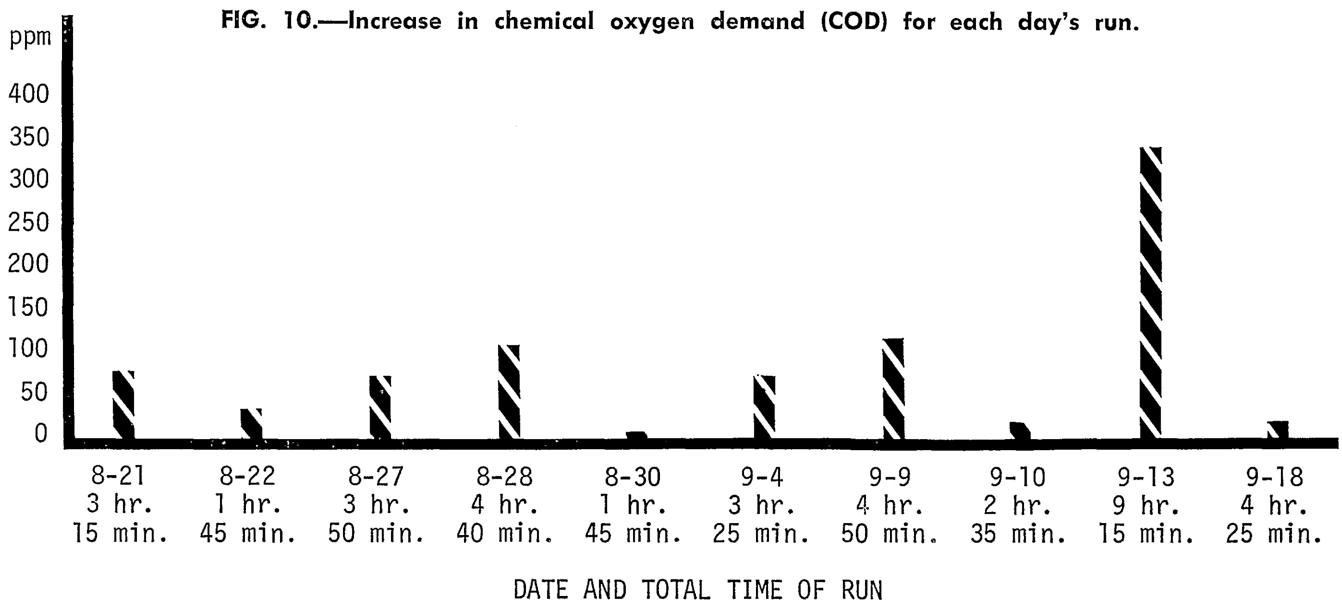



FIG. 10.—Increase in chemical oxygen demand (COD) for each day's run.



## SUMMARY

Differences were encountered early in the season while learning to operate the equipment. After the equipment parameters were known, however, it was definitely feasible to separate useable from unuseable fruits by the specific gravity water technique. Only one take-off conveyor is needed to remove the green fruit, with this being adjusted in depth and proximity to entry based on cultivars of tomatoes being run. An average efficiency for the C-28 cultivar ran as high as 97.0%, with a low of 61.0% for the Libby B cultivar. Overall, calculated efficiency was 80.0% for all cultivars.

The specific gravity equipment should permit the separation of the useable from the unuseable fruits. The useable fruits are removed with a drag conveyor in the bottom of the unit, removing all fruits which sink in the water. The conveyor located near the surface of the separator removes green and defective fruits.

Detergents are not necessary, but the temperature of the water should be adjusted, particularly when sorting cold fruits. The unit was more effective when the water in the separator was 20° F. higher than the fruit temperature.

Tomatoes can be machined harvested with little or no sort on the harvester other than labor for removing clods and vines. The dry disc cleaner is essential to keep the water clean in the separator. The tomatoes were cleaned efficiently with little or no buildup of solids or COD's in the separator. The dry disc cleaner did an excellent job of removing smear soil.

Man-hour records were maintained for each operation. Generally not more than two people were required for the final sorting of the tomatoes. One operator is required to operate the line and make adjustments due to the cultivar differences.

Defective fruits in the latter part of the season were removed with the separator in zone 1 or the unuseable belt. These were removed with the green fruits, indicating that entrapped air caused these fruits to rise rapidly in the water system.

The average specific gravity difference for the ripe fruits vs. the green fruits was 0.054, indicating that a definite difference was obtained. This principle was the one proven successful for separating useable from unuseable tomatoes.

In addition, the specific gravity separation equipment for tomato sorting with water can be operated day or night and the volume of tomatoes sorted is related to the capacity of the machine. The unit used in these studies was 32 x 4 x 5 feet and holds 4,600 gallons of water. It was operated at 3 tons per hour but never at maximum capacity or for any 24-hour period. The FTC Corporation indicated the equipment has a capacity of 15 tons per hour. During one 9¼-hour run, sorting 24,595 lb. of tomatoes with breaks between each 1,000 lb., the COD in the separator increased to 345. This could indicate the possible need to clean or change the water in the separator for extended runs. However, no difficulty or loss of efficiency in sorting the tomatoes was noted.

## REFERENCES

1. Kattan, A. A., R. H. Benedict, G. A. Albritton, H. F. Osborne, and C. Q. Sharp. 1968. Mass Grading Machine-Harvested Tomatoes. Arkansas Farm Research, 17(1).
2. Kattan, A. A., C. Q. Sharp, and J. R. Morris. 1969. A Mechanical Sorter for Tomatoes. Arkansas Farm Research, 18(1).
3. Gutterman, R. P. July 1974. A Mass Flow Density Sorter for Fruits and Vegetables. Food Technology Corp., Rockville, Md., personal communication.

# *The State Is the Campus for Agricultural Research and Development*


Ohio's major soil types and climatic conditions are represented at the Research Center's 13 locations.

Research is conducted by 15 departments on more than 7200 acres at Center headquarters in Wooster, eight branches, Green Springs Crops Research Unit, Pomerene Forest Laboratory, North Appalachian Experimental Watershed, and The Ohio State University.

Center Headquarters, Wooster, Wayne County: 1953 acres
Eastern Ohio Resource Development Center, Caldwell, Noble County: 2053 acres
Green Springs Crops Research Unit, Green Springs, Sandusky County: 26 acres
Jackson Branch, Jackson, Jackson County: 344 acres
Mahoning County Farm, Canfield: 275 acres
Muck Crops Branch, Willard, Huron County: 15 acres
North Appalachian Experimental Watershed, Coshocton, Coshocton County: 1047 acres (Cooperative with Agricultural Research Service, U. S. Dept. of Agriculture)
North Central Branch, Vickery, Erie County: 335 acres
Northwestern Branch, Hoytville, Wood County: 247 acres
Pomerene Forest Laboratory, Coshocton County: 227 acres
Southern Branch, Ripley, Brown County: 275 acres
Western Branch, South Charleston, Clark County: 428 acres